

## CLAIMS

What is claimed is:

1. An apparatus for image data computation and for synchronous image data output, comprising:

- an external input unit;

- at least one signal input which can be connected thereto;

- a first message channel;

- a graphics master unit which has a first random access memory adapted to receive a first scene graphics data file which defines objects and/or events which can be illustrated in an image and associates object and event parameter values respectively with the objects and/or events, is connected to the signal input, is connected by way of a first message interface for incoming and outgoing messages to the first message channel and which is adapted to re-compute and store the object and/or event parameter values of the first scene graphics data file in dependence on the current object and/or event parameter values thereof and the current state of the signal input and to produce and send a first message by way of the first message interface, wherein the first message contains at least a part of the freshly computed object and/or event parameter values;

- at least two graphics client units, wherein each graphics client unit has a respective second random access memory which is adapted to receive a second scene graphics data file, is connected by way of a second message interface for incoming and outgoing messages to the first message channel, has an image data output, and is adapted to receive current object and/or event parameter values by way of the second message interface and to store the received object and/or event parameter values in the second scene graphics data file, to compute image data of an image in dependence on current object and/or event parameter values of the second scene graphics data file, to produce and send a second message to the graphics master unit by way of the second message interface which signals the conclusion of the image data computation of the image, and to output the image data at the image data output.

2. The apparatus of claim 1 characterized in that the graphics master unit is additionally adapted to produce a third message and to send the third message to each graphics client unit after receiving the second message from each graphics client unit and each graphics client unit is additionally adapted to output the image data at the image data output after receiving the third message.

3. The apparatus of claim 2, wherein the graphics master unit has writing and reading access to a third random access memory which is connected to the second random access memory and in which at least one scene graphics data file is stored, wherein a respective memory address and/or scene graphics identification number is associated with each scene graphics data file contained in the third random access memory.

4. The apparatus of claim 3, further comprising:

- a second message channel, associated with the graphics master unit;

- a synchronization master unit connected to the graphics master unit, having a third message interface for incoming and outgoing messages, which connects same to the second message channel, and which is adapted to produce a fourth message in which is contained the memory address of a scene graphics data file and/or the scene identification number of the scene graphics data file and to send the fourth message by way of the third message interface, associated with each graphics client unit a respective synchronization client unit connected to the associated graphics client unit, having a fourth message interface which connects it to the second message channel and which is adapted to receive the fourth message at the fourth message interface and to subsequently cause loading of the scene graphics data file defined in the fourth message into the second data memory and to produce and send a fifth message which signals conclusion of loading of the scene graphics data file, to the synchronization master unit by way of the fourth message interface.

5. The apparatus of claim 4, wherein the synchronization master unit and the synchronization client unit respectively are additionally adapted to produce a first test message and a second test message respectively, to produce a first test answer

message after reception of the second test message at the third message interface and to produce a second test answer message after reception of the first test message at the fourth message interface, and to send the respective test and test answer message by way of the second message channel.

6. The apparatus of claim 5, wherein the graphics master unit is adapted for real-time computation of the object and event parameters and the graphics client unit is adapted for real-time image data computation.

7. The apparatus of claim 6, wherein the graphics client unit and the graphics master unit are in the form of browsers for the file format VRML, Inventor, Performer and/or X3D.

8. The apparatus of claim 7, further comprising:

in association with each graphics client unit, a respective graphics computing unit having a data input for image data, by way of which it is connected to the associated graphics client unit which has a signal output for control signals for controlling a display unit of an image reproduction device and which is adapted to convert image data received at the input into control signals and to output the control signals by way of the signal output.

9. The apparatus of claim 7, further comprising:

a partial image switching unit for each two graphics client units, having a signal input, at least one first and at least one second image data input which are each associated with a respective graphics client unit, a first and a second image data intermediate memory connected to the first and second image data input respectively, an image data output for each pair of first and second image data inputs, which is adapted to output the image data either of the first or the second image data intermediate memory by way of the image data output in dependence on the state of the signal input, and a switching control unit which is connected at the output side to the signal input of the partial image switching unit and which is adapted to produce and deliver at least one control signal at a predeterminable signal delivery frequency.

10. The apparatus of claim 9, further comprising:

a graphics computing unit which is connected to the image data output of the partial image switching unit which has a signal output for control signals for controlling a display unit of an image reproduction device, and which is adapted to convert image data received at the input into control signals and to output the control signals by way of the signal output.

11. A graphics master module comprising:

an external input unit;

at least one signal input adapted to receive signals therefrom;

a first message interface which is adapted to send and receive digitally encoded messages;

a first random access memory for receiving at least one scene graphics data file which defines objects and/or events which can be represented in an image and which associates object and event parameter values with the objects and/or events respectively;

image parameter computation means which are connected to the first random access memory and the signal input and to the message interface and which are adapted to compute object and/or event parameter values of the first scene graphics data file in dependence on the current object and/or event parameter values thereof and the current state of the signal input; and

master control means which are connected to the image computation means and the message interface and which are adapted to produce and send a first message by way of the first message interface,

wherein the first message contains at least a part of the computed object and/or event parameter values.

12. The graphics master module set forth in claim 11, wherein the graphics master module is additionally adapted to produce a third message and to send the third message to each graphics client unit after receiving the second message from each

graphics client unit and each graphics client unit is additionally adapted to output the image data at the image data output after receiving the third message.

13. A graphics client module comprising:

- a second message interface which is adapted to send and receive digitally encoded data;

- a second random access memory for receiving at least one second scene graphics data file which defines objects and/or events which can be represented in an image and associates object or event parameter values with the objects and/or events respectively;

- an image data output, and

- image data computation means which are connected to the second message interface and the second data memory and are adapted to store the object and/or event parameter values received at the second message interface in the second scene graphics data file, to produce image data of an image in dependence on current object and/or event parameter values of the second scene graphics data file, to output the produced image data at the image data output, client control means which are connected to the message interface and to the image data computation means and which are adapted to produce and send a second message to the graphics master unit by way of the second message interface which signals the conclusion of image data computation of the image.

14. The graphics client module as set forth in claim 13, wherein the graphics client module is adapted to receive a third message produced and sent by a graphics master unit after receiving the second message from the graphics client module and the graphics client module is additionally adapted to output the image data at the image data output after receiving the third message.

15. An image switching module comprising:

- at least one first and at least one second image data input;

- an image data output, associated with each pair of first and second image data inputs;

a first and a second image data intermediate memory which is associated with the first and the second image data input respectively, which is connected on an input side to the first and second image data input respectively and adapted to store image data and to output stored image data by way of the associated image data output in response to a first and a second control signal respectively;

a switching control unit having a signal output by way of which it is connected to the first and the second image data intermediate memories and which is adapted to produce and deliver the first and second control signals in alternate sequence at a predeterminable signal delivery frequency.

16. The image switching module as set forth in claim 15 characterized in that the switching control unit is adapted for additionally delivering the first and second control signals in the form of electromagnetic radiation, in particular infra-red radiation.

17. The arrangement for producing and simultaneously reproducing at least two partial light images which together can be perceived as a light image having a three-dimensional effect, comprising:

at least one scattering surface which is adapted for polarization-maintaining scattering of light into a spatial region which in relation to light incident on the scattering surface extends either in front of or behind the scattering surface;

two light image projectors associated with a respective scattering surface as image reproduction devices, which each have a control input and which are adapted to convert a respective number of control signals received at the control input into a respective raster light image composed from light pixels in matrix form and to project the respective raster light image using polarized light, wherein the polarization of the light respectively used by each of the two projectors is oriented differently, and which are arranged to project the respective raster light image onto the associated scattering surface;

an apparatus for image data computation and for synchronous image data output as set forth in claim 8, which has in association with each light image projector a respective graphics computing unit wherein the signal output of the respective



light and which illuminate the respective scattering surface from outside the hollow space, wherein the scattering surfaces scatter the incident light into the hollow space behind the respective scattering surface.

24. An arrangement for producing and reproducing in succession in respect of time at least two partial light images which together can be perceived as a light image having a three-dimensional effect, comprising:

at least one scattering surface which is adapted to scatter light into a spatial region which in relation to light incident on the scattering surface extends either in front of or behind the scattering surface;

at least one light image projector as an image reproduction device, which is associated with a respective scattering surface and which has a control input and which is adapted to convert a number of control signals received at the control input into a raster light image composed from light pixels in matrix form and to project the raster light image and which is arranged to project the respective raster light image onto the scattering surface;

an apparatus for image data computation and for synchronous data output as set forth in claim 9 which has associated with each light image projector a first and a second graphics client unit, wherein the image data output of the respective graphics client unit is connected to the first and the second image data input respectively of the partial image switching unit, and wherein the first and second graphics client unit is adapted to compute the raster image data of a partial image, reproducing the field of view of the left or right eye respectively of a viewer, of an image defined by the current object and/or event parameter values of the second scene graphics data file.

25. The arrangement as set forth in claim 24 characterized by two mutually perpendicular scattering surfaces.

26. The arrangement as set forth in claim 24 characterized by five mutually perpendicular scattering surfaces on a floor in such a way that the scattering surfaces and the floor delimit an approximately cubic hollow space, and by a light image



projector for each scattering surface, which illuminates the respective scattering surface from outside the hollow space.

27. The arrangement of claim 17, wherein:  
the light image projector or projectors are LCD or DLP projectors.

28. The arrangement of claim 17, further comprising:  
a PC-sound card connected to the graphics master, an audio amplifier connected to the sound card, and at least two loudspeakers connected to the audio amplifier.

29. The arrangement of claim 17 comprising a first and a second flat scattering surface, wherein the planes defined by the scattering surfaces include an angle, characterized in that the first and second scattering surfaces adjoin with mutually facing edges a third flat scattering surface in such a way that the third scattering surface adjoins each of the first and second scattering surfaces at a respective obtuse angle.

30. The arrangement as set forth in claim 29 characterized in that the intersection straight lines of the planes defined by the three scattering surfaces extend in mutually parallel relationship.

31. The arrangement as set forth in claim 30 characterized in that the intersection straight lines of the first and second planes with the third plane are each at the same spacing from the intersection straight line of the first plane with the second plane.

32. The arrangement of claim 31 characterized in that the first and second planes include an obtuse or a right angle.

33. The arrangement of claim 32 characterized in that the third scattering surface is of a widthwise extent of at least 60 cm.

34. The arrangement of claim 33 and an apparatus as set forth in claim 10 characterized in that each graphics client unit is adapted to compute and output in each case at least two partial image portions in such a way that a first partial image portion appears free from distortion on the first or second projection surface for a viewer from at least one position and that a second partial image portion appears distortion-free on the third projection surface from the same position.

35. A method of synchronously computing and outputting image data of at least two partial images of an image, in which the partial images are cyclically re-computed in the form of digital partial image data in dependence on image parameter values and/or current input signals and the partial image data are outputted after each computation cycle, characterized in that at the same time a master process and for each partial image a respective client process are executed,

wherein the master process comprises the following steps:

recomputing image parameter values in dependence on existing image parameter values and/or current input signals;

sending at least a part of the re-computed image parameter values to all client processes;

waiting to receive readiness signals from all client processes, and

the respective client process comprises the following steps:

receiving the re-computed image parameter values from the master process, after reception of the image parameter values computation of the respective partial image in the form of digitally encoded image data,

sending a respective readiness signal to the master process, and

outputting the respective partial image.

36. The method as set forth in claim 35 characterized in that the master process additionally includes a step of sending an image change signal to all client processes after reception of all readiness signals and the client process additionally includes a step of waiting for reception of the image change signal from the master process.

37. The method of claim 36 characterized in that the image parameters are computed in dependence on the master process by externally transmitted input data.

38. The method of claim 37 characterized in that after reception of the readiness signal from all client processes the master process jumps back to computation of the image parameter values of a fresh image and after the image change the client process jumps back to receive the image parameter values from the master process.

39. The apparatus of claim 1, wherein the graphics master unit has writing and reading access to a third random access memory which is connected to the second random access memory and in which at least one scene graphics data file is stored, wherein a respective memory address and/or scene graphics identification number is associated with each scene graphics data file contained in the third random access memory.

40. The apparatus of claim 1, further comprising:

- a second message channel, associated with the graphics master unit;

- a synchronization master unit connected to the graphics master unit, having a third message interface for incoming and outgoing messages, which connects same to the second message channel, and which is adapted to produce a fourth message in which is contained the memory address of a scene graphics data file and/or the scene identification number of the scene graphics data file and to send the fourth message by way of the third message interface, associated with each graphics client unit a respective synchronization client unit connected to the associated graphics client unit, having a fourth message interface which connects it to the second message channel and which is adapted to receive the fourth message at the fourth message interface and to subsequently cause loading of the scene graphics data file defined in the fourth message into the second data memory and to produce and send a fifth message which signals conclusion of loading of the scene graphics data file, to the synchronization master unit by way of the fourth message interface.



the signal input, and a switching control unit which is connected at the output side to the signal input of the partial image switching unit and which is adapted to produce and deliver at least one control signal at a predeterminable signal delivery frequency.

46. The apparatus of claim 45, further comprising:

a graphics computing unit which is connected to the image data output of the partial image switching unit which has a signal output for control signals for controlling a display unit of an image reproduction device, and which is adapted to convert image data received at the input into control signals and to output the control signals by way of the signal output.

47. The arrangement of claim 17, characterized by two mutually perpendicular scattering surfaces which are adapted for back-scattering of light.

48. The arrangement of claim 18, characterized by two mutually perpendicular scattering surfaces which are adapted for back-scattering of light.

49. The arrangement of claim 17, characterized in that the scattering surfaces are metallic.

50. An arrangement for producing and reproducing in succession in respect of time at least two partial light images which together can be perceived as a light image having a three-dimensional effect, comprising:

at least one scattering surface which is adapted to scatter light into a spatial region which in relation to light incident on the scattering surface extends either in front of or behind the scattering surface;

at least one light image projector as an image reproduction device, which is associated with a respective scattering surface and which has a control input and which is adapted to convert a number of control signals received at the control input into a raster light image composed from light pixels in matrix form and to project the raster light image and which is arranged to project the respective raster light image onto the scattering surface;

an apparatus for image data computation and for synchronous data output as set forth in claim 10, which has associated with each light image projector a first and a second graphics client unit, wherein the image data output of the respective graphics client unit is connected to the first and the second image data input respectively of the partial image switching unit, and wherein the first and second graphics client unit is adapted to compute the raster image data of a partial image, reproducing the field of view of the left or right eye respectively of a viewer, of an image defined by the current object and/or event parameter values of the second scene graphics data file.

51. The arrangement as set forth in claim 50, further comprising two mutually perpendicular scattering surfaces.

52. The arrangement as set forth in claim 50 characterized by five mutually perpendicular scattering surfaces on a floor in such a way that the scattering surfaces and the floor delimit an approximately cubic hollow space, and by a light image projector for each scattering surface, which illuminates the respective scattering surface from outside the hollow space.

53. The arrangement of claim 24, wherein:  
the light image projector or projectors are LCD or DLP projectors.

54. The arrangement of claim 50, wherein:  
the light image projector or projectors are LCD or DLP projectors.

55. The arrangement of claim 24, further comprising:  
a PC-sound card connected to the graphics master, an audio amplifier connected to the sound card, and at least two loudspeakers connected to the audio amplifier.

56. The arrangement of claim 50, further comprising:

a PC-sound card connected to the graphics master, an audio amplifier connected to the sound card, and at least two loudspeakers connected to the audio amplifier.

57. The arrangement of claim 24 comprising a first and a second flat scattering surface, wherein the planes defined by the scattering surfaces include an angle, characterized in that the first and second scattering surfaces adjoin with mutually facing edges a third flat scattering surface in such a way that the third scattering surface adjoins each of the first and second scattering surfaces at a respective obtuse angle.

58. The arrangement of claim 50 comprising a first and a second flat scattering surface, wherein the planes defined by the scattering surfaces include an angle, characterized in that the first and second scattering surfaces adjoin with mutually facing edges a third flat scattering surface in such a way that the third scattering surface adjoins each of the first and second scattering surfaces at a respective obtuse angle.

59. The arrangement as set forth in claim 57 characterized in that the intersection straight lines of the planes defined by the three scattering surfaces extend in mutually parallel relationship.

60. The arrangement as set forth in claim 58 characterized in that the intersection straight lines of the planes defined by the three scattering surfaces extend in mutually parallel relationship.

61. The arrangement as set forth in claim 59 characterized in that the intersection straight lines of the first and second planes with the third plane are each at the same spacing from the intersection straight line of the first plane with the second plane.

62. The arrangement as set forth in claim 60 characterized in that the intersection straight lines of the first and second planes with the third plane are each at the same spacing from the intersection straight line of the first plane with the second plane.

63. The arrangement of claim 61 characterized in that the first and second planes include an obtuse or a right angle.

64. The arrangement of claim 62 characterized in that the first and second planes include an obtuse or a right angle.

65. The arrangement of claim 63 characterized in that the third scattering surface is of a widthwise extent of at least 60 cm.

66. The arrangement of claim 64 characterized in that the third scattering surface is of a widthwise extent of at least 60 cm.

67. The arrangement of claim 65 and an apparatus as set forth in claim 9 characterized in that each graphics client unit is adapted to compute and output in each case at least two partial image portions in such a way that a first partial image portion appears free from distortion on the first or second projection surface for a viewer from at least one position and that a second partial image portion appears distortion-free on the third projection surface from the same position.

68. The arrangement of claim 66 and an apparatus as set forth in claim 10 characterized in that each graphics client unit is adapted to compute and output in each case at least two partial image portions in such a way that a first partial image portion appears free from distortion on the first or second projection surface for a viewer from at least one position and that a second partial image portion appears distortion-free on the third projection surface from the same position.

69. The method of claim 35 characterized in that the image parameters are computed in dependence on the master process by externally transmitted input data.



70. The method of claim 35 characterized in that after reception of the readiness signal from all client processes the master process jumps back to computation of the image parameter values of a fresh image and after the image change the client process jumps back to receive the image parameter values from the master process.